Electronic Components and Methods for Producing Same

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the National Stage of International Application No. PCT/EP04/09729, filed September 1, 2004.

BACKGROUND

Field of the Invention

[0002] The invention relates to several methods for producing electronic components with adjacent electrodes tightly interspaced at distances ranging between 10 nanometers and several micrometers on a substrate of any type that may also be a polymer film or glass, except for substrates for standard semiconductor technology such as Si, SiO_2, Si_3N_4, GaAs, Al_2O_3.

[0003] The methods based on the invention find application in the extremely low-cost and simple manufacture of electronic components requiring the smallest electrode separation such as, for example, molecular electronics, polymer field-effect transistors or field emitters.

Description of Related Art

[0004] The State of the Art describes various lithographic procedures (DUV or electron-beam lithography) by means of which the shortest possible length of the electrically active channel within the transistor (channel length), and thereby a high operating speed, may be achieved. However, these high-resolution lithographic procedures are very cost-intensive and therefore not suitable for the application realms of low-performance, low-cost electronics.

[0005] Also, a method per Friend, published in SCIENCE 299, 1881 (2003), is known in which a vertical configuration of two lateral metallization layers separated by an insulating polymer layer is used in order to provide short channels in polymer transistors. A blade cuts into this sandwich so that closely adjacent electrode connections M_{e1} and M_{e2} are present at the

sidewalls. The polymer semi-conductor (`active layer`) is deposited over this V-slot, and then made into a transistor.

[0006] The disadvantage here, however, is that the material is deformed when pressed into the cut slot, and the opposing sidewalls of the channel are positioned very close to each other. The active layer subsequently deposited cannot be evenly distributed because of meniscus formation.

[0007] A method to produce contact structures within semi-conductor components is knows from DE 198 19 200 A1 according to which a recess is formed in the substrate using a mask. Two separate electrode structures may be applied to it by deposition of a conducting material and creation of flanks for the recess.

BRIEF SUMMARY

[0008] It is therefore the task of the invention to develop one or more methods with which closely adjacent electrodes may be structured on a substrate in a simple, low-cost manner, and thus allow the production of electronic components with the least possible technological expense.

[0009] In principle, structuring of the electrodes is performed by overlapping the edges on the deposited layer, or by means of undercutting the deposited layer. Finishing of the electronic components occurs subsequently either in a conventional manner or by means of a lithographic process from the underside of the transparent substrate and subsequent succession of known procedure steps to produce electronic components.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0010] The invention will be described in more detail using Figures of a field-effect transistor, which show:

[0011] FIG. 1 depicts structuring of electrodes by overlapping the deposited layer;

[0012] FIG. 2 depicts structuring of electrodes by undercutting a deposited layer;

[0013] FIG. 3 depicts production of a transistor using known methods;

[0014] FIG. 4 depicts production method for a field-effect transistor using photo-lithography from the underside of the substrate;

[0015] FIG. 5 depicts production of a field-effect transistor by etching into the depth of the substrate.

DETAILED DESCRIPTION

[0016] FIG. 1 shows the steps of a vertical production method. A photo lacquer 102 was deposited on a substrate 104 and was so structured that overlapping edges arise 106 on the photo lacquer 102. Subsequently, a metal vapor 108, preferably Chromium or Gold, is deposited. The insulator 110 applied in the subsequent procedure step covers the entire surface. Flat edges 112 are formed on the overlapping edges 106 of the photo lacquer 102 because of meniscus formation during the subsequent etching process as an inverse of the overlaps. The substrate 104 with its mounted and insulated electrodes 114 thus produced may be completed to produce a field-effect transistor 116 in subsequent procedure steps such as scattering the organic semiconductor (`active layer`) 118, deposition of another insulator, and gate metallization and exposure of the electrodes 114.

[0017] FIG. 2 shows another method to structure closely adjacent electrodes 202 on a substrate 104. In this method, a metal vapor 108, preferably Chromium or Gold, is deposited. Photo lacquer 102 is then deposited onto this metal layer 108, and is structured according to the components to be produced. In the subsequent method step, the metal 108 is etched at all points 204 not covered by the photo lacquer 102, whereby the metal 108 is over-cut at the edges of the photo lacquer 102 in a controlled manner.

[0018] Overhangs 206 thus are formed on each photo lacquer 102. Subsequently, the structure thus achieved again receives a deposit of metal

vapor 208. The electrodes 202 are separated from each other by means of the undercutting. After the photo lacquer 102 is removed (lift off) with its deposited metal layer 208, the desired electronic component (field-effect transistor) 116 may be completed using known method steps by scattering an organic semi-conductor (`active layer`) 118 and an insulator 110, or deposition of gate metallization 302 and exposure-etching 304 of the connectors (FIG. 3). To the extent the deeper-positioned electrodes are to be formed, for example, the gates of a transistor, they are purposefully so covered with an insulator that the recess is also closed by means of it.

[0019] FIGS. 2 and 4 show a production method for an electronic component with closely adjacent electrodes 202 on a substrate 104 for the example of production of a field-effect transistor 116. The structuring of these closely adjacent electrodes 202 results as in the above-mentioned method (Method 2) up to the point of scattering the insulator 110. A photo lacquer 402 is subsequently deposited onto this insulator 110, and photolithography is performed from the underside of the substrate 104. An absolutely necessary pre-condition for this is, however, that the substrate 104, the active layer 118, and the insulator 110 must be transparent. After this lithographic process, a subsequent metal-vapor layer 404 is deposited. In the final step, the remaining photo lacquer 402 with its deposited metal layer 404 is removed (e.g., by a lift-off process).

[0020] In order to avoid this lift-off process at the sub-micrometer level, the metal layer 404 may alternatively be structured by deposition of a suitable mask and etching to a width wider than the channel length. The gate sections positioned above the closely-adjacent electrodes 202 are separated by the photo lacquer 402 remaining under them to the point that the parasitic gate capacitances remain small as for field oxide (Diagram E in FIG. 4).

[0021] Another method to produce electronic components with closely adjacent electrodes 202 on a substrate 104 is shown in FIGS. 2 and 5 for the example of the production of a field-effect transistor 116. The structuring of these closely adjacent electrodes 202 is performed as in the above-described

method (Method 2). Holes or grooves 502 for one or more gates buried are etched into those positions of the substrate 104 at which no metal layer 108 is present. In the subsequent method step, a second vapor-metal layer 504 is deposited to the entire surface. Thin gate metallizations are deposited in the holes or grooves 502. An insulator 110 is subsequently deposited on the surface thus produced. The holes or grooves 502 are partially filled by the insulator 110. The insulation 110 is etched away on the upper side of the substrate 104 using, for example, a plasma process, and is only partially etched away in the holes or grooves 502 because of the aspect ratios. The organic semiconductor (`active layer`) 118 is subsequently applied. After the surface of the substrate 104 is sealed 506, the contacts of the buried gates must be exposed by means of a photolithographic process.

[0022] The methods based on the invention allow the production of electronic components with closely adjacent electrodes 202 whereby the structuring of the electrodes 202 is achieved by means of a single-mask process. Classical micro-structuring techniques may be used for this. Use of these methods allows simple, low-cost production of electronic components. The electronic components produced by the methods based on the invention may be reproduced better and more simply.

[0023] These methods may be applied advantageously in molecular electronics, to produce polymer field-effect transistors 116, field emitters, or other electronic components.